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ADVANCED NAVAL VEHICLE CONCEPTS EVALUATION (ANVCE) SHIP ACCELER--ETC(U)
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Advanced Naval Vehicle Concepts Evaluation (ANVCE) SHIP ACCELERATION LIMITS

(Contract N00167-76-M-8290)

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20. (cont.)

One would normally design to meet limits (B) and (D), accepting the more severe conditions (A and C) for only a small percentage of the total operational profile, or if very substantial advantages (such as greatly reduced cost, perhaps) accrue from operation at the more severe limit.

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Acceleration Limits
Ride Quality of Naval Vehicles

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this note is to define the tolerable acceleration limits for vehicles in the ANVCE study. In decreasing order of severity, these limits are:

Limit	Physiological Description (Experienced Navy Crew)
(A)	Severe, less than one hour
(B)	Tolerable, less than one hour
(C)	Long-term, severe
(D)	Long-term, tolerable

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ANVCE SHIP ACCELERATION LIMITS

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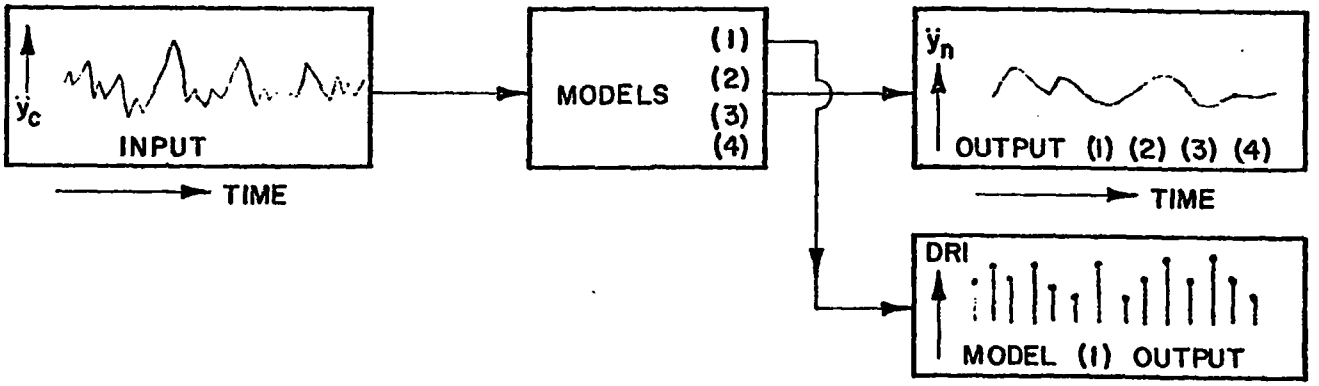
(D)	Long-term, tolerable

One would normally design to meet limits (B) and (D), accepting the more severe conditions (A and C) for only a small percentage of the total operational profile, or if very substantial advantages (such as greatly reduced cost, perhaps) accrue from operation at the more severe limit.

The physiological effect of the vehicle's acceleration time history ($\ddot{y}_c$) for a given set of operating conditions is assessed by exciting (or "driving") four dynamic models with it, and observing the model output ($\ddot{y}_n$).



The basic model equation is as follows

$$\ddot{\delta} + 2\bar{c}\omega_n\dot{\delta} + \omega_n^2\delta = \ddot{y}_c$$

$$\ddot{y}_n = \ddot{y}_c - \ddot{\delta}$$

where δ is the deflection of the spring of a simple sprung mass model, ω_n (rad/sec) is the natural frequency of the model, and $\bar{c}$ is the damping ratio.

Model Number	$\bar{c}$	ω_n (rads/sec)	Name
①	0.224	52.9	Spinal
②	0.40	25.1	Visceral
③	1.0	52.9	Body Vibration
④	1.0	1.571	Low Frequency

The VIBRATION RIDE QUALITY INDEX (VRQI) is defined as

$$VRQI = \frac{\ddot{y}_n'(RMS)}{g}$$

where $\ddot{y}_n'(RMS)$ is the maximum value obtained from one of the four model outputs.

The limits on VRQI are as follows:

Limit	Description	VRQI must be less than:
A	Severe, less than one hour	0.5
B	Tolerable, less than one hour	0.2
C	Long term, severe	0.2
D	Long term, tolerable	0.1

The IMPACT RIDE QUALITY INDEX (IRQI) is obtained from the "DRI" output of Model Number ①, the "spinal model."

$$DRI = \frac{\omega_1^2 \delta_{1\ MAX}}{g}$$

$\delta_{1\ MAX}$ is computed for each maximum value; i.e. each δ_1 when $\dot{\delta}_1 = 0$, $\ddot{\delta}_1 < 0$

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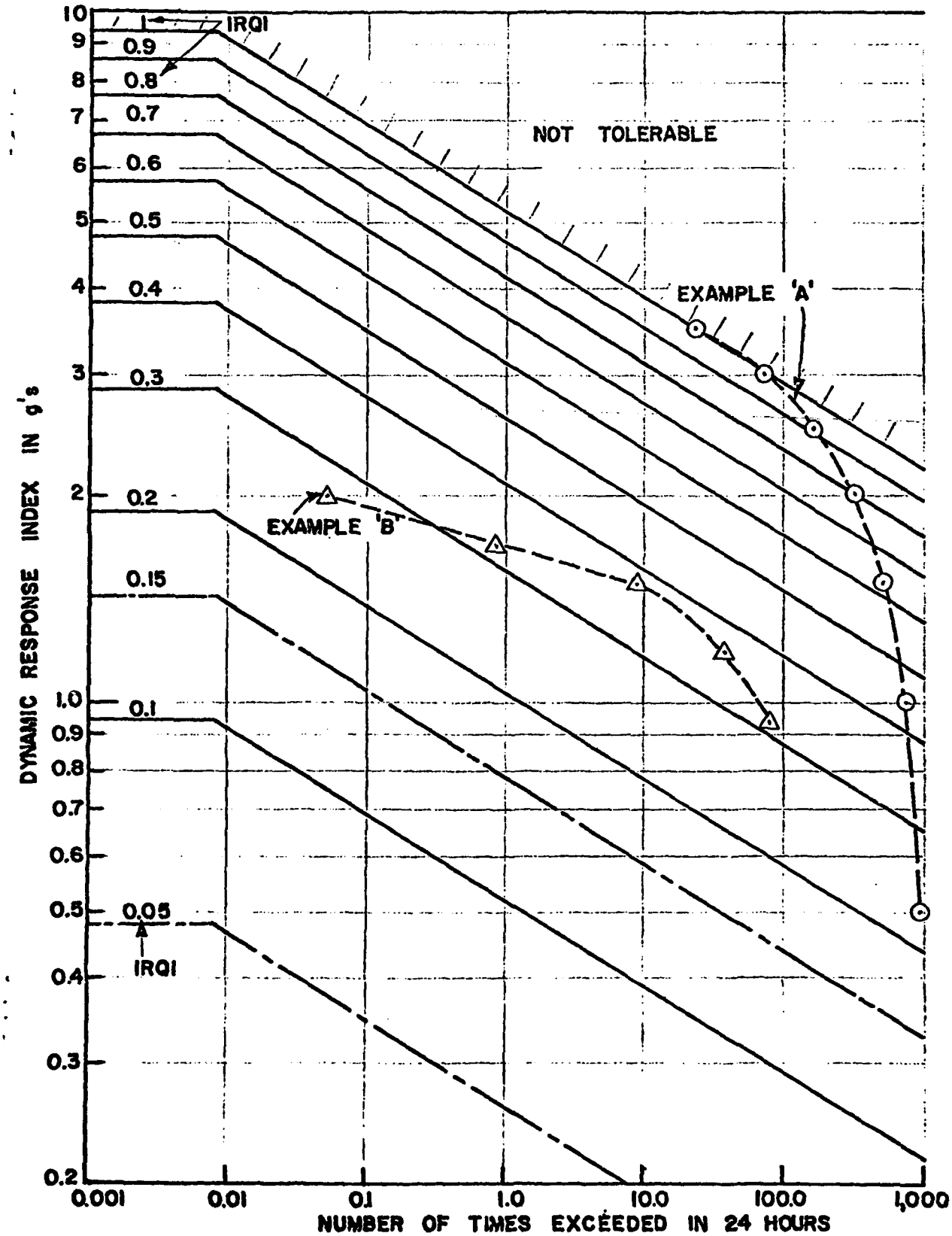
We now order the DRI values as in the following example:

DRI	Number of Occurrences/hr.	DRI Exceedance Point	Number of Exceedances/hr.	Corresponding Number of Exceedances in 24 hrs.
0 -0.5	109	0	149	3576
0.5-1.0	9	0.5	40	960
1.0-1.5	10	1.0	31	744
1.5-2.0	7	1.5	21	504
2.0-2.5	7	2.0	14	336
2.5-3.0	4	2.5	7	168
3.0-3.5	2	3.0	3	72
3.5-4.0	1	3.5	1	24
4.0-4.5	0	4.0	0	0
4.5-5.0	0	4.5	0	0

The exceedances per twenty-four hours are obtained by ratioing up from the duration for which readings were actually obtained; in this example, one hour. The exceedance points are then plotted as shown ("Example A") in Figure 1. The IRQI is defined as the largest value which occurs. In Example A, IRQI = 1.0, so that the ride is just at the limit of tolerability. In Example B, the maximum value is about IRQI = 0.38, indicating a relatively smooth ride.

Reference

1. Payne, P.R. "On Quantizing Ride Comfort and Allowable Accelerations." Paper to be Presented at the 3rd Advanced Naval Vehicles Conference, Arlington, Virginia (September 1976).


IRQI
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.15
0.1
0.05
IRQI
NOT TOLERABLE
EXAMPLE 'A'
EXAMPLE 'B'
DYNAMIC RESPONSE INDEX IN g's
10
9
8
7
6
5
4
3
2
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.001
0.01
0.1
1.0
10.0
100.0
1,000
NUMBER OF TIMES EXCEEDED IN 24 HOURS